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THE NATIONAL POTATO BREEDING PROGRAM

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The problems of potato improvement involved in breeding varieties superior to the present day commercial varieties in shape, smoothness, yield, earliness and cooking quality combined with resistance to various diseases, are numerous. These problems are not limited by state boundaries but are of sectional interest, some involving a comparatively large number of states and others of importance to all the potato-growing states. They all, then, may properly be considered of national importance.

About eight years ago potato breeding work was confined almost completely to two states, Maine and Minnesota. In Maine the U. S. Department of Agriculture, under the leadership of William Stuart and C. F. Clark, was working for new varieties with better market and cooking quality than the commonly grown commercial varieties. Krantz, of Minnesota, had specialized on earliness and fertility and had experimented with breeding methods, especially with the methods involved in selfing and the recombination of inbred lines.

Real progress had been made at both places. The U. S. Department of Agriculture had developed a number of varieties with almost ideal shape, with shallow eyes and, as it was later shown, with resistance to mild mosaic, one of the common virus diseases found in Maine. The University of Minnesota had succeeded in developing a comparatively large number of self fertile, early lines valuable for breeding purposes. It was the realization of the national importance of the problems with which the potato grower had to contend and of the possibilities of solving some of these problems through breeding methods which prompted E. C. Auchter,

Head of the Division of Fruit and Vegetable Crops and Diseases of the U. S. Department of Agriculture, to bring together at Chicago a group of horticulturists representing a number of potato-producing states to discuss the situation and propose plans for developing and expanding the potato breeding work. The outcome of this meeting was the organization of a national potato breeding program, the work of which was to be done by the U. S. Department of Agriculture and the state experiment stations working in close cooperation.

An appropriation had been received from Congress and steps were taken immediately to formulate memoranda of understanding with a number of state experiment stations. Formal agreements were entered into between the U. S. Dept. of Agriculture and the states of Minnesota, Iowa, North Dakota, Maine, Rhode Island, Michigan, New York (Cornell University), North Carolina and Louisiana. Informal cooperation was also begun with a number of other states until at present approximately 20 states are cooperating to a greater or less degree. When the organization was first begun there was relatively little formal cooperation between pathologists and breeders, but it soon became apparent that some of the most important problems involved disease resistance and that such problems could best be solved by the combined efforts of pathologists and breeders rather than by each group working independently. It is evident that a program of this nature requires research in genetics, pathology and physiology. The breeder must study the modes of inheritance of many characters in addition to resistance or susceptibility while the pathologist must study the nature, life histories of the causal organisms, and spread of the disease, and when a disease resistant problem is attacked they must work together on the same material. For example, the work of Dr. Schultz in describing the virus diseases of the potato and of separating out the various forms such as mild mosaic, latent mosaic, spindle tuber and leafroll, has made possible the studies of the inheritance of resistance to these various diseases, since there is no variety known resistant to all of these, and as a consequence an epidemic in which they were all involved would eliminate all varieties and strains of potatoes available, and a variety resistant to any one of them would be found only accidentally.

At this meeting it is proposed to take stock of some of the accomplishments of the national potato breeding program and the papers given are designed to emphasize some of the more important

accomplishments and at the same time form a basis for discussion of improvement and expansion of the work. These papers will appear in subsequent issues of the Journal. It may appear to some that disease resistance is being emphasized too much and that such characters as type, shallowness of eye, yield and cooking quality are being neglected, but this is not so. These characters are in the forefront in all our work and greater emphasis is given them now than ever before. For example, Cornell University and also Maine, Rhode Island and Michigan have been conducting formal cooking tests while the Bureau of Plant Industry, cooperating with the Bureau of Home Economics, tests a large number of seedlings and varieties every year. Many new varieties, otherwise promising, are discarded every year because they do not rank as high as they should in cooking quality.

The national potato breeding program is functioning and as will be seen by the papers which are to follow, important results have been obtained, but there are numerous problems of a fundamental nature which have scarcely been touched. A few of these problems might be mentioned.

- (a) Further work to determine the mode of inheritance of reaction to a number of diseases.
- (b) A study of the nature of disease resistance.
- (c) The nature and causes of sterility.
- (d) Cooking quality with especial emphasis on the characters which may be correlated with quality.
- (e) Blacking of the cooked flesh,—its causes and remedies.
- (f) Breeding methods; further work with selfing and recombin-
ing inbred lines in comparison with what might be called strain
building by a combination of sib mating, back-crossing and selfing,
the latter practiced not more than one or two generations.
- (g) The causes and inheritance of earliness.
- (h) Cytogenetic studies of hybrids.

It is sincerely hoped that with the horticulturists, pathologists, physiologists, and geneticists of the states and government working together, that many of the objects of the national cooperative potato improvement program will be accomplished.

DETERMINING THE VALUE OF A NEW POTATO VARIETY

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Within the past four years, three new varieties of potatoes, the Katahdin, Chippewa and the Warba, each one with distinctive characteristics, have been originated and submitted to the public for its approval.

When the potato breeder starts out to develop something new, he has definite objectives in mind, and through his method of analysis and synthesis he succeeds in originating a variety which partially, if not completely, approaches the standards set by him. The opportunity for observing the behavior of his new creation is confined largely to the area covered by his breeding plots, and it is through these observations that he determines whether or not the new variety has commercial possibilities. Primarily, he thinks of producing a new variety which will be a distinct improvement from the standpoint of yield, type and table quality over the present commercial varieties being grown in his state or in the region where he is doing his work. Secondly, he has in mind the general adaptability of the new variety.

Before introducing a new seedling as a new variety, it is desirable to determine, by means of numerous scattered tests, whether or not the commercial possibilities as observed by the breeder on his plots are well founded. In Minnesota we are fortunate in having sub-stations located at Duluth, Grand Rapids and Crookston, each station being in a potato growing area with conditions peculiar to the area. Material for general tests is produced at the sub-stations. The soil, rainfall, temperature, etc., at each sub-station differ from the conditions at the other two stations, so that we have a fairly good idea of what might be expected of a new seedling in our state before it is submitted to the growers for trial. The Katahdin, Chippewa, and Warba were first tested at all these stations before they were submitted to growers for trial.

In the Katahdin and Chippewa we have two varieties originated under growing conditions quite different from our own. The preliminary tests of these two varieties at our sub-stations indicated that both might have commercial possibilities for our growers. Through the courtesy of Dr. F. J. Stevenson of the Division of Fruit and Vegetable Crops and Diseases, U. S. D. A., we obtained a sufficient quantity of both these varieties to carry on more extensive tests with growers in representative regions of the state. The number of these tests was

increased during the two following years, and the first real commercial fields of Katahdins and Chippewa were grown in the state in 1934. We have now had two years in which to determine the commercial possibilities of these two varieties in Minnesota when grown on a commercial acreage.

Both of these varieties have done remarkably well on a number of different types of soil, and both have become very popular with the growers who have been growing them. One of the interesting facts concerning the Katahdin is its uniformity of type under a wide range of soil, moisture and temperature conditions. The Chippewa is somewhat similar in this respect, although on our peat soils, to which it is much better adapted than the Katahdin, it has a tendency toward flatness. Owing to the later maturity of the Katahdin, it is not so well adapted to the northern half of the state as is the Chippewa. Inasmuch as the most extensive potato growing regions are in the northern part of the state and because of its excellent performance under conditions existing in these regions, the Chippewa is in greater demand. Present indications are that it will be grown quite extensively in our state in the future.

Our first step in testing the Warba under field conditions was to pick out twelve dependable growers in the representative potato growing regions of the state. The growers selected were growers of certified seed. Each grower was furnished with a number of hill unit samples which were planted in hill units for purposes of comparison alongside the field being grown for certification. Planting by the hill unit method made it easy for the inspectors to look over the plots on their regular rounds and to rogue where necessary. Each grower supplied us with a portion of his crop, which, in turn, was divided into four-pound samples and offered to other certified seed growers on a "first come, first served" basis.

During this preliminary testing, numerous tuber graft inoculations with spindle tuber and mild, leafrolling, rugose and crinkle mosaic were carried on in the greenhouse. Pure cultures of the different types of mosaic were obtained through the courtesy of Dr. E. S. Schultz of the Division of Fruit and Vegetable Crops and Diseases, U. S. D. A. Similar inoculation tests now are made on all breeding material and on all prospective new varieties before they are turned over to growers for field tests.

The Warba showed a rather marked resistance to the different types of mosaic and because of this indicated resistance, its early maturity, and its productiveness, we felt that we had a potato that might

be of considerable interest to growers of Bliss Triumphs in the South, as well as an early market potato for our market gardeners.

At the end of the second year's trial by our growers, we had enough material to enable us to extend our tests to the early producing states in the South. These tests, conducted in ten states, largely through the cooperation of Experiment Station workers, county agents and growers, have furnished us with some interesting information on the behavior of this new variety under the conditions existing in these different states. Further tests in other states were run in 1934 and 1935. All of these tests, conducted with 15- to 20-pound samples, and extending from several hundred miles north of the Canadian border to the Gulf of Mexico and from the Atlantic to the Pacific coasts, in which the Warba was compared with the commercial variety or varieties grown in each particular region give a fairly good cross-section of what may be expected of the new variety when grown on a commercial scale.

However, the actual worth of a new variety is determined through demand of the consuming public, and the consuming public cannot pass judgment until a sufficient quantity is produced through commercial growing. The commercial grower is primarily interested in producing a large tonnage of marketable potatoes to each acre. Heavy tonnage avails him nothing unless his product "takes" with the public, but it is not always easy to obtain a reaction from the public as to the worth of a new variety unless it be produced on a commercial scale. From the standpoint of production on a commercial scale in Minnesota, records obtained from 64 certified seed growers this past growing season, which was not particularly favorable to an early maturing variety with as heavy a set as the Warba, showed that it equalled the Irish Cobbler. The small Warba test plots grown in various parts of the country indicate that in many regions it will yield heavily. Just what it will do under field conditions in these regions remains to be seen.

Since Minnesota is one of the states in which the Chippewa and Katahdin have been tested thoroughly through the medium of small plots, it is interesting to note the reaction to these two varieties by our growers. In appearance both of these varieties are equally attractive, and both should appeal to the consuming public. The Katahdin was tested in the representative potato regions of the state simultaneously with the Warba, while the Chippewa was received for testing two years later. Owing to the late maturity of the Katahdin, very few growers have continued to grow it. Possibly in the central and southern parts of the state it would, in time, supplant the Rural New Yorker. The Chip-

pewa, on the other hand, because of its earlier maturity, is increasing in popularity.

The average yield of nine fields of Chippewas being grown for certification this past summer was 215 bushels to each acre, while the average yield on six fields of certified Katahdins was 150 bushels to each acre. Had killing frosts held off another two weeks, it is entirely possible that the Katahdins might have outyielded the Chippewas. Because of the small number of fields, this comparison is probably not entirely fair, although all the fields were grown in the same general region. However, since we often have killing frosts as early as the 25th of August which may kill the vines completely in the northern half of the state and on the peat bogs in the southern sections, it is expected that the Chippewa will be more popular than the Katahdin in these regions.

The Warba, because of its extreme earliness, has attracted considerable attention both locally and throughout sections of the country where an early variety of high productiveness is desired. It is somewhat rough in appearance, being somewhat similar to the Irish Cobbler in this respect, although the degree of roughness varies with soil conditions. A number of cooperators report it as being quite smooth when grown under their conditions.

An important feature to consider in determining the value of a new variety is its cooking quality. A project designed to determine the relation of different factors to the cooking quality of Minnesota potatoes was begun two years ago by Miss Alice M. Child of our Home Economics Division. Primarily, we were interested in finding out if the same varieties grown on different types of soil reacted differently when prepared for the table in various ways. The Warba, Chippewa and Katahdin were included in these tests. It would be unwise for me to attempt to go into any detail relative to the manner in which these tests were conducted and to report the results. It might, however, be interesting to report the outcome of these tests briefly as regards these three new varieties. The preliminary results indicate that the cooking quality (baked, boiled, mashed and potato chips) of the Katahdin, when grown under Minnesota conditions, is inferior to the Chippewa and the Warba. From the standpoint of potato chips, the Chippewa was judged as the best potato for this purpose, all varieties included.

The potato breeder's evaluation of commercial possibilities, plot tests by growers—first under local conditions, then extended to growers in widely scattered regions, and the accumulation of favor-

able reports build up interest in the new production and pave the way for extended trials on a commercial scale. Closely linked with these tests should be the cooking trials which determine the table quality of the new variety. Although the grower thinks chiefly in terms of production, a new variety, besides being an improvement over existing varieties from the standpoint of yield, type, set of tubers, vine growth, etc., must also equal, if not surpass, the old varieties from the standpoint of table quality.

A REVIEW OF SOME CURRENT RESEARCH IN ENTOMOLOGICAL POTATO PROBLEMS

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This review attempts to summarize briefly papers dealing with potato insect investigations, particularly in the United States. The authors believe that the majority of papers of this nature relating to the 1934 and early 1935 seasons are included.

The abundance of the potato leaf-hopper (*Empoasca fabae* Harris) on beans and potatoes in Florida is reported in recent publications, and some new host plants are recorded (49, 63)*. From hibernation studies of this leaf-hopper and other related species in Ohio, it is reported that the potato leaf-hopper cannot survive the winter in northern states, but migrates from the milder climate of the southern states (17) each spring.

The relative value of different treatments in controlling the potato leaf-hopper is given in several papers (16, 54, 55, 60, 64). Among these treatments Bordeaux mixture was compared with sulphur and with sulphur plus pyrethrum with equally good results (16, 54, 55, 60). Sulphur either alone or with pyrethrum has been found to control this leaf-hopper, and to have a residual effect which delays re-infestation (15, 63). Deferred cutting of alfalfa has been found to control the potato leaf-hopper on alfalfa very satisfactorily (21, 56, 57), although the effectiveness of this treatment has been questioned (50).

Brief notes on the bionomics and food plants of some common potato aphids (*Myzus persicae* Sulz.), (*Macrosiphum solanifolii* Ashm.), and (*M. solani* Kalt) which are found in New Zealand are recorded

*Refers to literature cited.

(11). High relative humidity has been found to inhibit the migration of winged forms of *M. persicae* (13), and bordeaux sprayed leaves appear to be more attractive to *M. solanifolii* than the unsprayed leaves (48). (*Aphis abbreviata* Patch) appears to be implicated in the natural spread of potato mosaic (58).

Field tests in Tennessee indicate that strip farming increases the effectiveness of natural enemies of plant lice (45). Pyrethrum and derris dusts failed to control aphids (65), but nicotine sulphate and soap is recommended for aphid control where spraying is economically warranted (11).

"Psyllid yellows", a disease-like injury of potatoes caused by the feeding of a psyllid, *Paratriozza cockerelli* Sulc., has been found to be readily controlled by lime-sulphur applications to the plants (12, 35, 36, 37), while contact insecticides are useful in controlling the nymphal instars (30). The toxicity and repelling effects of sulphur appear to be the factors which determine the control of the psyllid (35, 36). The psyllid is able to breed on a number of common plants (31), but it has been found to have a number of insect predators (29, 30). One or two applications of lime-sulphur spray greatly increases the yield of potato tubers where psyllids are present (3, 4, 36, 37).

The life history of the potato flea-beetle (*Epitrix cucumeris* Harris) in Virginia is recorded (2). Increases in yield of potato tubers are reported as a result of controlling this flea-beetle (2, 59, 64, 67), however, these increases in yield are either small (59, 65), or probably caused by other factors (67). Organic thiocyanates were found to be toxic to the potato flea-beetle (66).

The Colorado potato beetle, (*Leptinotarsa decemlineata* Say), has become well established in France, and its spread is increasing (20). The potato plant appears to be more attractive to the potato beetle than other plants (20, 44). Bordeaux spray is reported to be toxic to larvae of this beetle (19), and derris dusts are effective against the adult (26).

Spraying experiments have been continued in an attempt to improve the effectiveness of the spray treatments with diverse results (7, 8, 9, 42, 43, 47, 59, 64). Long Island (47) and Maine (8, 59) report that spraying late in the season is more effective in increasing yields than applications made earlier in the season, but in western New York (42, 43) the largest increases in yield of tubers were obtained when the greater portion of the Bordeaux spray was applied early in the season. Some of the differences in results are undoubtedly

caused by differences in disease and insect infestations, although copper is reported to have a decided stimulating effect on the plant with resulting increases in yield (42). Reduction of the lime, either stone or hydrated lime, to one half the amount of copper sulphate in the bordeaux mixture was found to be desirable for the greatest increase in yield (7, 42, 43). High magnesium hydrated lime is suitable for spraying purposes, and on plants growing in magnesium deficient soils, gives greater increases in yield than calcium bordeaux (8). Copper-lime dusts have been found to give similar results to the bordeaux spray (43, 47). The size of experimental plots in relation to spraying experiments has been studied, and the number of plants required to measure differences in treatments has been calculated from field results (46). Other considerations in field plot technique have been enumerated (39).

Information has been collected which indicates that early planting of potatoes on Long Island lessens the effect of injury by insects later in the summer (27).

The clover leaf-hopper (*Agallia sanquinolenta* Prov.) is able to transmit potato yellow dwarf, and an aphis (*Myzus persicae* Sulz) has also been claimed to be a vector (28). The mite, (*Tarsonemus latus* Banks), is no longer considered to be the cause of a disease of the potato in New York which resulted in withering of the leaves (53).

Judging by references cited in the literature, wireworms appear, by far, to be the most important insect pests of the potato tuber. In general, the wheat wireworm (*Agriotes mancus* Say) is considered to be the species most injurious to potatoes (25, 41, 52), but this apparently depends somewhat upon the region and soil type encountered (33). Other species reported injurious to potatoes are (*Limonius ectypus* Say) (33, 41), (*Melanotus communis* Gyll), (41), (*Cryptophyphus abbreviatus* Say) (41), and (*Aeolus mellilus* Say) (41). Each of these species was reported to be more abundant in the lower, more poorly drained areas of the fields (22, 25, 41). Injury to tubers by *Agriotes* is in direct proportion to the larval populations within a field (24, 25, 52, 51), and there is a general increase in numbers of punctures in each tuber with a rise in larval populations (25, 41). Factors responsible for varying populations are reported to be cover crops, particularly hay and grain (10, 25, 38, 51, 52), soil types (22, 23, 24), soil moisture (32, 33, 38), organic matter content of the soil (22), and the soil reaction (32, 33). Some observers report that infestations are determined less by the kind, than by the sequence of crops, in a rotation (10, 33), and that the larvae (*Melanotus*) show little preference

in food plants, but are unable to live on humus (10). The importance of soil reaction, within narrow limits, is questionable (22).

Biological studies have been an important aspect of the investigations reported (25, 51, 52, 61, 62), and have been the basis for the most practical control recommendations for the wheat wireworm (25, 51, 52). The biology of (*Agriotes mancus* Say), (*Corymbites aeripennis* Kby.), and (*Pheletes ectypus* Say) is discussed in some detail (25, 32, 51, 52, 61).

Control experiments indicate that infestations of (*Agriotes mancus* Say) may be avoided by omitting sod crops from the rotation (25, 38, 51, 52), and larval populations can be decreased by continued cultivation (24, 25, 51). However, investigations in Ohio have failed to show a redistribution of the larval populations of this species in six different crop rotations, including sod crops and continuous cropping of potatoes (33). This author suggests that individual factors alone cannot be given credit for controlling wireworm distribution, but that the distribution is governed by a complex of several factors. Omitting grass from the rotations is not necessarily effective against *Pheletes agonus* (= *Limonius ectypus* Say) because the eggs of this species are apparently deposited in cultivated soils (33, 62).

Minor potato tuber pests reported upon include fungus gnat larvae (*Sciara* sp) and millipedes (*Diploiulus londinensis caeruleocinctus* Wood), which were responsible for injury from approximately 15 to 24 per cent of the tubers in western New York in 1931 and 1932 (40). The injuries appeared to be closely associated with the occurrence of potato scab. Soil applications of sulphur reduced these injuries materially when the hydrogen-ion concentration of the soil was reduced to below pH 5.00. The degree of effectiveness from this material fluctuated widely, probably because of regional soil differences.

Investigations on the potato tuber moth (*Phthorimaea operculella* Zell.) in Maryland indicated that winter survival of this pest in this region was successful only in well protected and sheltered locations. The characteristic types of injury are discussed (34). This pest was reported to be widely distributed in Iowa, but was not observed in sufficient numbers to do commercial damage (18). The same reference reports that the potato stalk borer (*Trichobaris trinotata* Say) caused considerable damage in Iowa in 1933.

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FURTHER STUDIES ON CONTINUOUS CULTIVATION AS A CONTROL FOR WHEAT WIREWORMS

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Surveys and field experiments in western New York have demonstrated that the Wheat Wireworm, (*Agriotes mancus* Say), is more destructive than any of the other species attacking potato tubers. The common potato rotation in western New York includes three crops—sod, potatoes and spring grain. The life cycle of the wheat wireworm is completed in three to four years and the beetles make their appearance every third and fourth year following sod. The coincident appearance of the sod crop and the beetles results in continued and increased infestations of wireworms.

Wheat wireworm infestations do not occur in cultivated fields for several reasons. Many writers (Fitch 1867, Hyslop 1916, Hawkins 1930, 1934) were of the opinion that wheat wireworm larvae were normally grass feeders and the beetles selected grasslands for oviposition. According to Hyslop, (1916,) cultivation during the summer

months may destroy pupae and beetles. MacLeod (1934) in a tentative explanation stated that the beetles were subject to desiccation as a result of cultivation and the absence of cover on cultivated fields during the egg laying period.

The presence of beetles on cultivated fields has been studied by the use of clover bait traps (Rawlins and MacLeod 1935). A heavily infested sod field was plowed in the spring of 1933 and planted to potatoes. This field was planted with rye which was plowed early in May 1934 and again planted to potatoes. Bait traps were placed in this field and the records shown in table 1 were obtained. The beetles appeared in May and had practically disappeared June 13. Egg laying in a field laboratory in this same region started June 10. During the drought of May and June 1934 (table 2) the top soil dried out and the beetles probably died of desiccation. Dead beetles could not be found in this field on June 13, 1934 because of frequent cultivation which presumably scattered and buried the beetles. Dead beetles under stones, dried lumps of soil and in the roots of upturned sods were found in other fields that had not been frequently cultivated.

Observations and experiments since 1930 have not confirmed the belief that wheat wireworm beetles migrate freely from field to field. Tanglefoot traps posted in fields, previously in sod, which were being cultivated and were heavily infested with beetles, did not capture many *Agriotes mancus* adults. Many *Melanotus* sp. and *Limonius* sp. beetles have been taken although larvae of these species are not common in most infested fields.

The rainfall for May and June 1935 (table 2) was about normal. Rains were frequent and the top soil did not dry out even with frequent cultivations. Trapping records were taken in two fields, one of which was a sod in 1933, and planted to potatoes in 1934 and 1935. The other field had been planted to sod in 1932, potatoes in 1933 and 1934, and oats in 1935. Beetles were present on these fields (table 3) until July 5 and it was impossible to find eggs in the soil taken from these fields but beetles dissected at frequent intervals indicated that the eggs had been laid after June 22. In the laboratory egg laying began June 6.

Square yard soil samples were taken from these experimental fields during the fall seasons of 1934 and 1935 and no young larvae were found in any of these samples. These results, together with observations of several other fields infested with *A. mancus* adults indicated that reinfestation did not occur in cultivated fields.

Further field studies of the wheat wireworm have demonstrated that continued cultivation is an effective and practical method of reducing wireworm populations and the resultant damage to potato tubers. When the surface soil of fields is dried out as a result of frequent cultivation, the beetles may be killed before eggs are laid. If rains keep the soil moist the beetles will probably lay eggs even in cultivated fields but no young larvae will develop in these fields. No evidence of an appreciable migration of beetles from field to field, was secured, and no cases of reinfestation of cultivated fields have been observed.

TABLE 1.—*The occurrence of wireworm beetles in a cultivated field during a dry season*

Date of Baiting	Number of Beetles	Remarks
May 28	146	Soil moist. Beetles under stones and lumps of soil.
May 30	122	Same as above
June 2	176	Field harrowed. Soil drying out.
June 5	34	Top soil dry.
June 13	1	Top soil very dry. Egg laying began June 10.
June 27	0	Potatoes cultivated.

TABLE 2.—*Summary of weather records for May and June 1934 and 1935, Castile, Wyoming County*

Month	Total Precipitation Inches	Departure from Normal	Number of Days with More Than .01"
May	1.80	-2.80	3
June	0.40	-1.07	5
May	3.25	-0.13	5
June	3.44	+0.14	10

TABLE 3.—*The occurrence of wireworm beetles in cultivated fields during a season of normal rainfall*

Field 1

Date of Baiting	Number of Beetles	Remarks
May 28	163	Potatoes planted. Soil moist.
June 7	189	Egg laying began June 6. Soil moist.
June 13	201	Soil drying out. Beetles under stones and lumps of soil.
June 14	701	Same as above.
June 30	21	Rainfall abundant. Soil moist.
July 5	8	Soil moist.

Field 2

Date of Baiting	Number of Beetles	Remarks
May 29	16	Oats planted. Not seeded with clover and timothy.
June 4	94	Soil moist.
June 11	24	Egg laying started June 6 in field laboratory.
June 22	10	Soil moist.
June 29	12	Soil moist.
July 1	6	Soil moist.

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DATE OF DIGGING AND ITS RELATION TO THE DEVELOPMENT OF RHIZOCTONIA ON POTATO TUBERS¹

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Next to the virus diseases of potatoes, scab and scurf are perhaps the most important from an economic standpoint. Inspection officials almost everywhere are concerned about the standards and tolerances which should be applied when dealing with these tuber diseases. All are of the opinion that the presence of either scab or black scurf detracts from the general appearance of the stock concerned and affects its salability. This applies not only to seed potatoes but also to commercial stock. Therefore, it should be the aim of every potato grower to produce a crop of clean-skinned tubers. In fact, in these days of keen competition and demand for high quality, the grower who produces an inferior product is likely to suffer severe financial losses.

Considerable experimental work has been conducted in an endeavor to determine whether seed treatment is effective in controlling common scab and Rhizoctonia. Some have reported more or less positive results, others the reverse. When one assumes that seed treatment cannot be effective if the soil is already infested with the organisms causing these diseases, the point is reasonably taken. What the potato grower needs is some practical method of soil treatment for the control of Rhizoctonia or some method of crop rotation by which the action of the fungus is limited on the potato crop.

Seed treatment experiments conducted over a period of years at Charlottetown have produced more or less negative results, possibly because the soil used was heavily infested with the Rhizoctonia fungus. Similar experiments conducted elsewhere have produced rather contradictory evidence of the efficacy of various seed treatments.

If the seed is affected, then seed treatment may be of some benefit by preventing the introduction of the organism into the soil or the prevention of sprout and stem infection. The latter is a moot question since we do not know whether the stem infection arises from the sclerotia on the tubers or from the action of the organism already in the soil, or from both. How is the average grower to determine whether

¹Contribution No. 443, from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Ontario, Canada.

or not his soil does or does not harbor the organism? It has been stated that most soils, whether cultivated or virgin, already contain the Rhizoctonia fungus and it then becomes a question of crop rotation. In this case, crops such as small grains or corn, or an expensive soil treatment, must be used in an endeavor to keep the disease in check. Not only is this true for the potato grower, but it applies in like measure to growers of other crops, such as beans, beets, carrots, cotton, eggplant, lettuce, peas, sweet potatoes, and tomatoes, all of which are reported as being susceptible to Rhizoctonia infection in one form or another.

By advancing the harvesting date some measure of control of the sclerotial form of the rhizoctonia disease on potatoes has been attained at the Charlottetown Station. This experiment was started in 1924, with Irish Cobblers only, and has been conducted since that date with the exception that in 1926 and 1935, both Irish Cobblers and Green Mountains were included.

The object of the experiment was to determine what influence, if any, the date of digging had in limiting the amount of black scurf on the crop of tubers. The normal digging date for Cobblers in this section is about September 20th, and for Green Mountains is October 1st. In these experiments, harvests were made from September 1st to October 13th. The results of nine years experiments are shown in the accompanying table.

Table I—The relationship between date of digging and the per cent of Rhizoctonia (Black scurf)

Date Harvested	September					October	
	1	8	15	22	29	6	13
Irish Cobblers	2.33	5.41	14.51	26.07	30.18	37.70	43.07
Green Mountains	0.2	1.67	8.31	16.96	27.78	34.14	39.55

From these results it will be seen that there is a considerable increase in the number of diseased tubers from week to week.

The results also indicate clearly that on heavily infested soil the normal digging date is actually too late. On the other hand it is reasonable to assume that on soil not so heavily infested a considerable degree of safety exists on these dates, and that hastening the harvest date by one or two weeks will result in a comparatively clean crop even

in years when conditions are favorable for the development of the fungus.

It must be borne in mind, however, that the practice of early harvesting must be conducted carefully since immature tubers are liable to injury at harvest time, and consequently are rendered more susceptible to storage losses.

From the certified seed growers' standpoint early harvesting is to be recommended. He should test his crop from time to time by digging a few hills here and there throughout the field as the regular harvest date approaches and should be prepared to harvest the entire crop on the first appearance of sclerotia on the tubers.

The procedure, therefore, of digging the potato crop at as early a date as possible, either just prior to or immediately after maturity, is a practice to be recommended when the rhizoctonia disease is a factor to be considered.

SECTIONAL NOTES

COLORADO

The matter of introducing the Golden potato in Colorado was taken up with a number of marketing organizations. The consensus of opinion, however, was that it would require too much money to finance a campaign to educate the buying public on the merits of this variety.

The Colorado State Seed Show was held at Colorado Springs February 3 to February 8, inclusive. Approximately two hundred samples of potatoes were entered. The quality of all these samples was unusually good, and the competition was keen. Sweepstakes of the show were won by a sample of Irish Cobblers grown on dryland by John Sherman of Craig, Colorado. Reserve sweepstakes were won by a sample of Dark Red Peachblows or Red McClure's grown by Howard Macy of Center, Colorado.

The Colorado Potato Growers' Exchange has been testing out a washing machine at their Center plant during the winter. Most of these washed potatoes have been packed in 15 pound cotton bags. This is an experiment to test the possibilities of the premium for washed stock and also to determine the keeping and carrying qualities of washed stock.

Red McClure potatoes from the San Luis Valley have been packed in cotton bags which are bringing a premium of 15 cents per hundred on the Chicago market.

All the potato districts have plenty of snow in the mountains to assure adequate irrigation. Water prospects appear very favorable for a normal crop this year. (Mar. 10).—C. H. METZGER.

GEORGIA

At a recent meeting of the Horticulturists of the Experiment Stations and College of Agriculture, it was decided to recommend only certified seed potatoes for planting this year. In all probability the acreage of potatoes will exceed the acreage planted during the past. (Mar. 13).—H. L. COCHRAN.

IOWA

Potato plantings will apparently be normal in this region for the 1936 crop. In general, this territory is well supplied with subsoil moisture and this factor always favors a good yield.

One of the factors in the situation is the relatively high price of seed. Carlots of good selected seed f.o.b Iowa points range from \$1.30 to \$1.40 per hundred. This means that receivers will have to get \$1.50 to \$1.60 per hundred for Cobblers, Ohios, or Triumphs that are not certified. Premiums for certified seed are apparently not so high this year, but will probably amount to 25 cents per hundred. Planters of good certified Cobbler seed who buy less than a carlot, will have to pay approximately \$2.00 to each hundred.

One large grower is planting 100 acres of Warbas on upland ground. There is a question as to how the consuming public will take to so rough a potato as the Warba. The fact that it sets heavily will tend to keep down the size and so prevent the potatoes from becoming too rough. There is no doubt that the Warba is highly productive or that it is early and vigorous. It is a much better producer, for instance, than the Triumph ordinarily is.

The new Iowa law written by the author and adopted by last winter's legislature through the efforts of Senator Elthon and Representatives Kringlaak and Hansen is being put into effect at the present time. It is likely we shall have very little more false branding of seed potatoes in this state, which had reached intolerable proportions, and something had to be done about it. (Mar. 12).—C. L. FITCH.

LOUISIANA

Louisiana has planted a normal crop of potatoes this year; that is, approximately 225 cars of Northern Certified Seed potatoes. Planting of the crop has been rather irregular because of weather condi-

tions. The planting period began the latter part of January and continued until the first week in March. This difference in planting was caused primarily by the extremely rainy period which occurred during early February. At present seed pieces are germinating in the early plantings.

The potato growers will be glad to know that Dr. William Stuart is now conducting some special fertilizer studies for the Clovelly Farms, located on the muck soil area near Cut Off, Louisiana.

The tentative dates for the annual Louisiana Potato Tour and meeting of the Louisiana Certified Seed Growers' Association and Potato Growers' Association are April 15 and 16. We take this opportunity to invite any out-of-state visitors who might be interested in potato improvement work, to be with us at that time.—JULIAN C. MILLER.

MAINE

During the last few days the growers in Maine have been treated to a reappearance of the optimism once appearing frequently in the potato business. Markets have advanced sharply. Sales are being made today on the basis of \$1.45 per hundred f.o.b. for U. S. No. 1 in contrast to the price ten days ago of \$1.10 per hundred, f.o.b. This advance of 35 cents is very welcome. Shipments to date have been slightly over twenty-nine thousand cars, with an expectation of forty-two thousand cars for the season.

Maine is in a strong position to maintain a fairly uniform movement for the balance of the season, and at the same time maintain, or still further improve, the present price level. These statements are based upon the delayed season in the South, together with the fact that our supplies are not burdensome, and also because of the fact that we will probably not experience excessive competition in our normal selling territory for the remainder of the year.

In all probability there will be a recession, but in general, prospects are favorable for price levels being maintained or pushed higher.

At the Aroostook Production Credit Association no interest has been manifested, as yet, in making applications for loans for this season. It is expected that beginning with March 16 applications will begin to come in. An effort is being made to spread the time of making applications so that the burden will not fall at once as it has in the past. It is to be hoped that growers will cooperate with this program.

The results of marketing the crop controlled by the Aroostook Production Credit Association are seen as increasingly beneficial to the entire industry. Loans will be made this year on the same basis as last

so far as taking payment in potatoes is concerned. That is a very hopeful development.

Little is known at present of intentions to plant for the year 1936. It is reasonably assumed however that there will be somewhat of an increase with the season closing out so satisfactorily. This increase is not expected to be very significant however.

An outstanding development which is being witnessed here is the tremendous change in attitude toward cooperative activity. Growers are becoming more conscious of benefits accruing from organizations operating in their own interests rather than in the interest of the few who have formerly controlled them.

Important strides will be made in the progressive development of this idea during the next few years. It is encouraging to all of us interested in the potato industry. (Mar. 14)—FRANK W. HUSSEY.

NEBRASKA

An agreement on contract price has already been reached between the processor and sugar beet growers. Moisture conditions are favorable for the production of sugar beets. Last year neither of these conditions existed and the result was a large potato acreage. This year with an increased acreage of sugar beets, the potato acreage will probably be smaller. However, no information on intentions to plant is available at this time.

One of the largest crops of Triumphs ever produced in the North Platte Valley was produced last year. At the beginning of the shipping season farms received 60c. cwt., for No. 1's; at the height of the season they received 70-80c. cwt.; and at the present time they are being paid 90-95c. cwt. Commercial seed has been selling for 75c. cwt. and certified for 90c. cwt. (Mar. 8).—LIONEL HARRIS.

NORTH CAROLINA

Our potato growers are just completing their planting this week. The winter weather was so severe that early plantings were impossible and practically no potatoes were planted until after the middle of February. It is my understanding that Virginia and Maryland are also planting and South Carolina has just finished. Therefore it is possible that these crops may be harvested at the same time which will make a bad market situation. (Mar. 11).—ROBERT SCHMIDT.

OREGON

Our main potato area is in the Klamath District. In 1934 they shipped five thousand cars of which four thousand originated in Oregon and one thousand in the adjacent Northern California counties. Frost cut the shipments last year to approximately thirty-five hundred on an increased acreage. The acreage will be slightly larger again this year and probable shipments will be nearly five thousand cars again.

In 1934 tonnage was moved into the Los Angeles market for the first time by some radio advertising. The Klamaths outsold the better known Idaho Gems from fifteen to twenty cents a hundred throughout the season after this advertising campaign was started.

The acreage in other parts of the state will undoubtedly show a decrease. Most of the Oregon crop has moved at prices from \$1.10 to \$1.60, which growers consider satisfactory, but crops have been light because of drought and October freezes. Certified seed has moved mostly at \$1.50 or higher.

Considerable interest has developed in Katahdins, since they are rather drought resistant. Trials in Eastern Oregon show that the Warba is extremely susceptible to scab, and Chippewa very resistant. Chippewa, therefore, may have a place in this state.

A large number of our growers are suberizing their seed for the summer plantings. They cut the seed two days ahead of planting, then hold them at temperatures from 60 to 65 degrees and sprinkle two or three times a day. Perfect stands are secured even when soil temperatures are rather high. (Mar. 13).—E. R. JACKMAN.

PENNSYLVANIA

Our acreage will probably be about normal. One thing which will tend to bring this about is the shortage of good seed. A great many of our growers sold their potatoes last fall before the price went up so that they are not feeling so optimistic, as the present price might lead one to believe.

The Cobbler acreage has increased very rapidly in recent years, but last year some growers sold their Cobblers at so low a price that they were very much discouraged and will probably be planting a larger percentage of late potatoes this year. (Mar. 9).—J. B. R. DICKEY.

SOUTH CAROLINA

The potato acreage in South Carolina this season will be approximately 9,500 acres as compared to 8,500 acres in 1935; most of the increase being in Charleston and Beaufort Counties.

The weather has been fairly favorable, with the exception that plantings were delayed a few days because of excess moisture. Practically all the potatoes were in the ground by February 22nd and plantings were completed by March 1st. With favorable weather conditions from now on our shipments should start about the usual time, from May 10th to 15th. (Mar. 11).—GEO. E. PRINCE.

TENNESSEE

We are enjoying some fine spring weather after a very cold winter. The ground is dry enough to work, and we are planting early potatoes this morning. It is too early for us to forecast much about the potato situation in this state. If good weather continues for at least a few days more, most of the crop will be planted. (Mar. 10).—BROOKS D. DRAIN.

WISCONSIN

In recent days shipments of certified seed potato stocks have been moving fairly rapidly from Wisconsin; especially certified seed stocks of the Triumph variety.

The unusual freeze occurring early in October, 1935, has reduced the available seed stocks in several sections of the state and this will result in considerable increase in the movement of seed potatoes in Wisconsin to supply deficient areas.

Plans for the potato acreage appear to be practically normal and we do not look for much change from acreage conditions as existed in 1935. Unusual interest is manifested by the growers in the trial of the newer varieties, mainly the Katahdin and Chippewa introduced by the U. S. Department of Agriculture. Both of these varieties will be produced on a field scale this year in several sections of the state. This should furnish interesting comparisons with the leading standard late varieties raised in Wisconsin, namely the Rural New Yorker, Russet Rural, and Green Mountain.

REVIEW OF RECENT LITERATURE

A note on the effect of handling on the respiration of potatoes,
JOHN BARKER (*New Phytologist*, Vol. 34, (1935), pp. 407-408).

Potato tubers which possess a firm turgid flesh can be subjected, without serious disturbance of their respiration, to careful handling. If, however, old shrivelled potatoes, which have been kept at 60° F. for 15 months, are merely pressed with the fingers there is an immediate increase of about 30 per cent in the respiration and the rate remains high for about 10 days.—ORA SMITH.

The action of growth substances on the germination of the seeds and on the formation of cork in potato tubers, G. BORZINI (*Boll. Staz. Patol. Vegetale*, Vol. 15 (1935), pp. 323-337).

Growth substances induce a deeper formation of cork in cut potato tubers. The peptoglucose solution, the same that has been used as a nutrient medium for the growth of Rhizopus, has given a more abundant formation of cork in comparison with the untreated tubers.—ORA SMITH.

Degeneration of potatoes, E. S. MOORE AND J. SELLSCHOP (*Farming South Africa*, Vol. 10, (1935), pp. 431-433).

Under ordinary cultural conditions potato stocks deteriorate rapidly in South Africa and after a few years the progeny of imported seed becomes unprofitable for further cultivation. Seed must be imported at frequent intervals from cooler climates in order to maintain the vigor of the strain.

This paper discusses the nature of virus diseases affecting potatoes, their methods of infection such as cutting knives and aphids and describes the symptoms of leaf roll and the mosaics.

Evidently the investigators in South Africa are not yet convinced that the virus diseases are the sole cause of degeneration. Detailed experimental examination of abnormalities found in South African potatoes is not yet complete. Some think that the degeneration of potatoes is largely the result of rogue "wild" forms.

Pending further knowledge on this subject, certain definite lines of practice are emphasized: (1) the importance of securing seed certified to be free from virus diseases and rogue types; (2) the importance of maintaining the health and purity of the crop during the growing season and (3) the importance of improved methods of seed selection.

The Union imports annually from 500 to 2000 tons of seed potatoes, enough to plant approximately 5 per cent of the total

acreage. Much of this seed, however is of poor grade being inspected on entry into South Africa only for fungal and bacterial diseases.—ORA SMITH.

A potato seed plot roguing experiment, F. C. STEWART (*New York State Agr. Exp. Sta. Bul. 655*, (1935)).

Through the use of an isolated and carefully rogued seed plot for growing the seed plants it has been possible for a grower in Northern New York to produce a high grade of certified Green Mountain potatoes from fields of 6 to 8 acres during nine consecutive years. The experiment was begun in 1924 with seed containing 2.6 per cent virus diseases and ended in 1932 with a crop in which the official inspector found a total of only 0.4 per cent of virus diseases in two inspections.

It is believed that the success attained in this experiment was due chiefly to (1) the favorable location where high temperatures occurred but rarely and where aphids were not often plentiful on potatoes; (2) to the earliness and thoroughness of the roguing and (3) to the use of the tuber unit method of planting in the seed plot.

By the continuance of these methods it is probable that this strain of potatoes could be maintained at the same high standard of health indefinitely.—ORA SMITH.

The influence of various amounts and kinds of potash fertilizers upon the yield and quality of the potato, BERKNER, F., AND SCHLIMM, W. (*Landwirtschaftliche Jahrbücher*, 76, pp. 783-808, 1933).

The investigations reported in this paper deal with the effect upon the potato crop, of various forms of potash fertilizers when applied in different amounts at planting or blooming time, with calcium nitrate applied at three rates, to land in which little or no potassium deficiency existed and which was practically neutral in reaction. The experiments were conducted at Breslau, Germany. In these experiments the starchy variety Cellini was used.

The best stands occurred in the potassium or potassium-manganese sulphur plats, with poorer stands when potassium chloride KCl (40%) was used and very poor stands with kainit. Stands were poorer as rate of potassium applications increased. The effect of fertilizer application at blooming time was not apparent until the ripening period. It was very evident that the pale leaf color was due to the chlorine in the fertilizer. Where sulphates were used plants were a deep dark green.

The length of the vegetative period was increased by applications of potassium (K) especially with increased amounts of nitrogen (N.)

This was especially noticeable with heavier applications of kainit, where the tops of the plants grew considerably after blooming time.

Yield increases were not very great because the soil showed only a slight, or no deficiency in potassium. In comparison with the unfertilized check, the highest yields were secured as a result of the sulphate applications. Kainit decreased the yield, this decrease being greater with increased applications and with planting time application, and KCl gave only small increases. Yields increased with increased rates of application and no damaging concentrations were observed, even in dry years. With heavy applications of calcium nitrate, vegetative growth was very luxuriant and yields were reduced. With fertilizer applications at blooming time, yields, with the chlorine-containing fertilizer, were higher than when applied at planting time and also higher than the checks. Time of application did not appreciably alter yields when sulphates were used.

The percentage of small tubers was greatly increased by kainit, and reduced with sulphates, but with KCl their relative production was variable. The percentage of large tubers was least with kainit and greatest with sulphates.

The starch content of tubers from all fertilizer treatments was lower than in those from the checks. Tubers produced with chlorine-containing fertilizers lowered the starch content with greatest reduction when kainit was used, but the blooming time applications caused least depression. Potassium sulphate also caused a slight reduction, with time of application of no apparent consequence.

The amount of starch produced was significantly reduced with chlorine-containing fertilizers while with sulphates the starch yield was increased, especially when applied late in conjunction with heavy nitrate applications.

Plant destruction due to *Phytophthora* was prevalent in all plats. Second growth of tubers ("durch wuchs") was noticeably apparent only in the kainit plats. The rust spotting (*Eisenfleckigkeit*) was least prevalent with kainit, especially with early and heavy applications, and increased with the use of sulphates.

The percentage of nitrogen-free dry matter in tubers paralleled the starch occurrence, being very low and tubers watery when chlorine-containing fertilizers were used. The protein content increased as N applications increased and was greatest when K was applied at planting time. As the protein content increased the starch content decreased. The ratio of starch to protein was greatest with late K applications and light N applications.

Fat content was very low, but was highest with light N applications in plats receiving K at planting time. When chlorine fertilizers were used, fat content was highest when K fertilizers were applied at planting time, but with sulphates, highest percentage occurred when applied at blooming time.

Ash content decreased with increased N applications. The absolute amount of K taken up increased as the amounts available increased, and with the increased length of time that the plants were exposed to it, but decreased as the N application was increased. Greatest K absorption occurred with the chlorine-containing fertilizers, especially kainit. Luxury consumption was not so great when sulphates were used.

The chlorine absorption increased as it was available for a longer time and decreased as N applications increased. It was greatest with kainit followed by KCl and was least when sulphates were used.

Sulphur absorption also increased as its availability was increased and decreased with heavy N applications.

The crude fibre content increased with N fertilizer increases, and although the amount was increased by early application of K, the form of K seemed to be of no consequence. Sulphates appeared to reduce the amount of scab.

On the basis of cooking tests, tubers from N deficient plats were considered the best tasting. Potatoes from sulphate plats required least time for cooking and had a better taste than those from the KCl or kainit plats (the latter being distinctly inferior). Upon standing the KCl potatoes turned gray or black more quickly than did those from the kainit plats. The quality improved as sulphate applications were increased. Sulphates mitigated against blackening of cooked potatoes. This characteristic is believed to be associated with the higher dry matter content.—H. O. WERNER.

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IMPROVING THE POTATO INDUSTRY BY VOLUNTARY EFFORT

Voluntary efforts by potato growers to improve conditions in the potato industry have not been particularly successful. Not only have the growers failed to control the acreage to be planted in the past, but efforts to stabilize the industry in other ways have, for the most part, met with serious obstacles.

It was recently announced, for example, that the marketing agreement and the license for shippers of potatoes grown in the southeastern states were terminated April 10. The Long Island growers report also that it is extremely doubtful whether the grower-dealer committee will function this year. This committee has been in operation for the past two years. In 1934 it met each day to discuss market conditions and to agree on the action to be taken the following day. In 1935 it functioned only a portion of the season because some of the parties concerned failed to carry out the recommendations of the committee.

In New Jersey a successful Central Sales Office was operated in 1933 and again in 1934. Since some growers and dealers did not cooperate, however, it was decided to discontinue the office in 1935. After several weeks of falling prices the Central Sales Office was hurriedly revived. There is some question as to whether the plan will be continued this year since it appears to be impossible to enlist all dealers and growers in the organization. However at the present time a committee is working to determine what can be done to devise a method whereby the distribution of the New Jersey crop may be improved.

Possibly the difficulties in the potato industry cannot be completely eliminated on the voluntary basis. It may be that California has the solution of the problem. The article by H. G. Zuckerman in this issue of the Journal suggests that progress is being made in this direction. Other plans are being contemplated which should be watched with considerable interest. A solution of our difficulties, although very much to be desired, is not yet at hand.